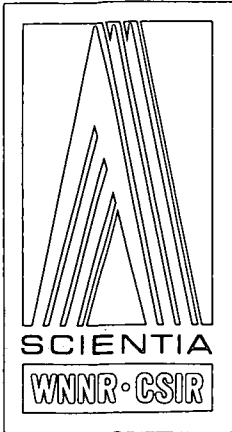


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TO ASSESS THE VALUE OF SATELLITE IMAGERY IN
RESOURCE EVALUATION ON A NATIONAL SCALE

February 1973

Type II Report for Period July 1972 to January 1973

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NATIONAL PHYSICAL RESEARCH LABORATORY
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15. Abstract: ERTS imagery of South Africa, mainly in the form of 1:10 ⁶ scale black and white prints of MSS bands, was evaluated for its information content with respect to (a) soil and terrain mapping; (b) plant ecological mapping; (c) geological mapping and (d) urban and regional land use mapping, at scales below 1:250 000. It is concluded that ERTS imagery can make a significant contribution to accelerate and lower the cost of such surveys. Production of 1:500 000 colour composites will remove some of the limitations encountered.		

P R E F A C E

This report is divided into six sections:

Section I covers the introduction, indicates important gaps in ERTS coverage of South Africa and also describes the present and planned photo reproduction procedures.

Section II describes the results of the evaluation for small scale soil and terrain mapping, particularly its contribution towards finalizing the first national 1:1 500 000 terrain type map.

Section III, the evaluation for plant ecological surveys, is subdivided into four separate projects, the first three of which cover vegetation mapping in respectively the Central Natal, the Highveld Grassland and the Northern Transvaal Bushveld. The fourth project proves the utility of ERTS data in detecting the degradation of valuable grassland to scrub.

Section IV, the geologic investigation, tentatively indicates the value of ERTS, mainly for fast regional tectonic analysis and mapping.

Section V establishes the contribution ERTS could make towards accelerating land use surveys on a sub-national, regional and sub-regional scale and its value and limitations for urban studies.

In Section VI the significant results and their relationship to practical applications are summarized.

TABLE OF CONTENTS

	<u>Page</u>
<u>I. GENERAL</u>	3
1. Introduction	3
2. Data Received and Coverage	3
3. Photo Reproduction	4
4. Management and Funding	5
<u>II. SOIL AND TERRAIN MAPPING</u>	6
1. Objective	6
2. Scope of Activity	6
3. Analyses, Findings and Techniques	7
3.1 General appraisal of earth features and patterns	7
3.2 Terrain-type mapping	9
4. Conclusions and Recommendations	10
<u>III. PLANT ECOLOGICAL SURVEYS</u>	11
<u>A. Central Natal (Tugela River Catchment)</u>	11
1. Objectives	11
2. Methods	11
3. Results	12
4. Discussion and Conclusions	13
<u>B. Highveld Grassland</u>	14
1. Objective	14
2. Approach	14
3. Results	15
3.1 Ecological mapping	15
3.2 Sundry observations	16
4. Conclusions	17
M a p	18

	<u>Page</u>
<u>C. Northern Transvaal Bushveld</u>	19
1. Objectives and Approach	19
2. Results	20
3. Discussion	22
M a p	23
<u>D. Mapping of a Degraded Ecological Type</u>	25
1. Objectives	25
2. Method	25
3. Results	26
4. Conclusions	26
M a p	27
<u>IV. GEOLOGIC INTERPRETATION</u>	28
1. Objectives	28
2. Scope of Activity	28
3. Discussion	28
3.1 Geomorphology	28
3.2 Lithology	29
3.3 Regional tectonics	29
4. Conclusions and Recommendations	31
<u>V. URBAN AND REGIONAL LAND USE SURVEYS</u>	32
1. Objectives	32
2. Method	32
3. Results	32
3.1 Urban areas	32
3.2 Rural areas	33
4. Conclusion	34
M a p	35
<u>VI. SUMMARY OF SIGNIFICANT RESULTS</u>	36
1. Soil and Terrain Mapping	36
2. Plant Ecological Mapping	37
3. Geology	40
4. Regional Land Use Mapping	41

I. GENERAL

1. INTRODUCTION

In terms of the 'Provisions for Participation' a Type II report is required for the period ending 23 January 1973. However, for this proposal a Type I report may have been more appropriate at this stage since the first good quality ERTS images were only received about three months ago.

This period was consequently mainly devoted to reorganize photo-reproduction facilities to match the characteristics of the received imagery and to get acquainted with the characteristics of ERTS imagery.

Due to the limited time available, only selected samples of ERTS imagery could be studied in detail and interpretations could usually not be verified by field observations.

Furthermore these images were obtained during a period (September to October, early spring) which, for vegetation at least, is generally the least favourable season of the year. Later imagery of the same scenes received recently show a much greater variety of recognizable features.

The results reported here should therefore be regarded as incomplete and tentative. By the end of the next six month period a more conclusive and comprehensive assessment of ERTS data should be possible.

2. DATA RECEIVED AND COVERAGE

The first data received on 6 October 1972 were disappointingly poor RBV images. On 19 October 1972 the first MSS images were received, which proved to be of much better quality.

Up to the end of the report period imagery for about 150 ERTS scenes have been received, giving almost complete, relatively cloud free coverage of the Republic of South Africa.

The priority 1 test sites A, C and D of the original proposal have almost completely been covered twice or thrice. On the other hand it was disappointing that a large area of the priority 1 test site D (bounded by 29°S and 20°E) has not been covered yet. This fact was brought to the attention of the technical monitor, Mr George Ensor, at G.S.F.C.

3. PHOTO REPRODUCTION

Owing to the fact that the 70 mm negative transparencies were much denser than expected and some unexpected internal problems, the planned photo-reproduction procedures had to be rearranged. Furthermore some time was lost in experimentation on finding the 'best' format (in terms of both cost and utility) for reproduction in appreciable quantities. Consequently a delay was experienced in providing co-investigators and their assistants with copies of ERTS data.

At present the backlog which has developed has been caught up with and copies of imagery can be in the hands of users a couple of weeks after receipt of the NPDF products.

A standard procedure for reproduction of $1:10^6$ scale B/W paper prints is being followed:

From the NPDF 70 mm positive transparency a $1:10^6$ scale negative is produced which is then used by the Trigonometric Survey Office in Pretoria to produce $1:10^6$ scale B/W prints. This office routinely produces contact copies of the rational airphoto coverage and $1:10^6$ scale ERTS prints can therefore be handled in a similar way.

Selected scenes have been enlarged to 1:500 000 and 1:250 000 scale by the same agency for user evaluation. Some internal problems will have to be solved before these formats will be available freely.

Samples of directly printed colour composite $1:10^6$ scale prints and enlargements up to 1:250 000 scale have been lent by Mr Gilbertson of Spectral Africa (P.I. of ERTS-1 investigation SR-0577) to the co-investigators of this investigation. These have proven to be so useful that attempts will be made to make available 1:500 000 scale colour composites of most South African ERTS scenes.

Preliminary experiments have been carried out with $1:10^6$ scale photolithographic colour composite printing. Positive transparencies of bands 4, 5 and 7 have been used as colour separation positives to produce $1:10^6$ scale screen negatives (133 degree). These have produced prints which are of surprisingly good quality if examined with the unaided eye only.

The next step will be to produce similar prints at a scale of 1:500 000 which will have about 1900 screen points per scan line (compared to 2500 elements per scan line for the MSS). Provided a sufficiently large number of these are needed, they could be produced at a cost comparable to the 1:10⁶ B/W prints.

During the next six month period it is hoped to produce these prints to be used by co-investigators and their assistants for analysis and interpretation.

4. MANAGEMENT AND FUNDING

This investigation is managed by an ERTS Investigators Committee under chairmanship of the Principal Investigator and the co-investigators and representatives of the Trigonometric Survey Office, the South African Air Force and Spectral Africa (Pty) Limited who provide support services, as members.

The Council for Scientific and Industrial Research, the Department of Agricultural Technical Services and the Department of Agricultural Credit and Land Tenure have provided funds for the acquisition of an additive colour viewer, aircraft underflights and photo reproduction.

II. EVALUATION OF ERTS 1 IMAGERY FOR SMALL SCALE SOIL AND TERRAIN MAPPING AND INVENTORIZATION

Co-investigator : Dr J.M. de Villiers

Assistant investigators: Prof. D.J. Belcher
Mr G.P. Kruger
Dr D. Scotney

Soil and Irrigation Research Institute
Department of Agricultural Technical Services
Pretoria

1. OBJECTIVE

The objective of the project is to evaluate the applications of earth satellite imagery to small-scale soil and terrain mapping and inventorization of these natural resources on a national scale. The inventory which is currently being conducted by conventional ground methods throughout the entire Republic of South Africa aims at providing relevant information on which to base optimal and rational land-utilization. Consequently, present land-use is also of interest.

2. SCOPE OF ACTIVITY

Field staff throughout the Republic are engaged in demarcating natural regions on the basis of homogeneity of soil pattern (associations) and terrain type (using a modified and expanded Hammond procedure). These two factors (soil association and terrain morphology) define the basic mapping unit which has been called the 'pedosystem': significant changes in either or both of the factors define a pedosystem boundary. This mapping unit is proving to have very great practical significance and to be appropriate for small-scale (1:250 000 and smaller) mapping. Satellite imagery is being introduced into this programme to accelerate the field operations, to confirm and refine boundaries plotted in the field and possibly to reveal boundaries overlooked during the field survey. At the time of reporting, available satellite imagery has been applied for checking a preliminary terrain-type map of the Republic which has been prepared by a staff geomorphologist by means of morphometric analysis of the published 1:50 000 topo-cadastral series. Because of certain local problems experienced to date with the supply of 1:500 000 enlargements of the available ERTS imagery, it has not been

possible to disseminate the material to field staff and thereby initiate the in loco investigations projected. It is anticipated that the afore-said obstacle will soon be surmounted, whereupon these investigations will commence.

3. ANALYSES, FINDINGS AND TECHNIQUES

3.1 General appraisal of earth features and patterns

The objective of this phase was a general evaluation of earth patterns and their correlation with conditions established by other sources of ground data. Back-up information included:

- (1) Aerial photographs
- (2) Topographic maps
- (3) Geological maps
- (4) Vegetation maps

Sample images were taken as test areas to include a range of atmospheric, climatic, topographic, geological, ecological and land-use conditions.

The images chosen were 1:10⁶ black and white prints (mainly MSS bands 5 and 7) of:

- (i) 1047-07173 Rio Save (north), Rio Limpopo (S.W.) includes portions of Rhodesia, Mocambique and South Africa.
- (ii) 1047-07193 Tugela Basin, Durban.
- (iii) 1047-07184 Swaziland, Komatipoort.
- (iv) 1049-07301 Johannesburg, Pretoria.
1049-07364 Bloemfontein.
- (v) 1069-07411, 07414 Botswana, Zeerust, Mafeking, Lichtenburg.
- (vi) 1069-07423 Kimberley, Vaal River.

The primary conclusions reached are:

- (a) The 1:10⁶ scale black and white prints made available are not suitable for land-use studies. Image quality is too low and variable and the scale too small for the take-off of consistently useful information.

- (b) The use of colour additive viewing enhances land-use patterns to some extent but much of the required detail remains below the threshold of satisfactory identification. The viewing equipment is essentially unavailable to the main body of users.
- (c) Scenes that have been processed to 1:500 000 false colour form give excellent results, overcoming to a considerable degree the handicap of scale inherent in the 1:10⁶ black and white prints. However, these are essentially unavailable at the present time.
- (d) The 1:500 000 false colour record obtained on a seasonal basis appears to hold excellent prospects for supplying information on land-use. Growing crops in large fields, winter biological activity (winter cereals, irrigation), various types of woodland including exotic tree plantations are readily identifiable. Grassland and savanna which has been burned can be distinguished unambiguously by spectral band differentiation but kinds of land-use and management other than those mentioned are not reliably identified.
- (e) Roads can be located depending upon the degree of contrast between the road and adjacent land. Although major roads in urban areas are most frequently invisible, minor roads having a dirt, stone or calcrete surface can be detected as a result of natural contrast and lineal continuity. The principal railway line between Cape Town and Johannesburg via Kimberley is readily seen in large part due to cultural patterns along the line. Dry sandy creeks running in straight courses along faults or fractures may easily be mistaken for roads.
- (f) Contrast again is the key to the location of river and stream channels. Dry sandy creeks are quite visible; rivers with numerous sand-bars highly visible; sections of broad rivers with well-vegetated banks invisible. The Rio Save appearing on 1047-07173 demonstrates this clearly. Here the braided channel sections are in marked contrast to adjacent banks, and the waterfilled channel also provides

strong contrast with the dry sandy stream bed. On the contrary, in 1049-07364 (Bloemfontein) the streams leading to the Rusfontein, Tierpoort, Krugersdrif, Erfenis and Allemanskraal reservoirs are indistinct to invisible when dissociated from the typical reservoir image. Major reservoirs by virtue of their unique shape and strong contrast are clearly visible.

Drainage lines cannot be followed in most instances. For example, the Tugela River is not visible in its lower course.

The above details are needed for reference in land-use studies. Without them, or with time-consuming search needed to locate them, the benefits to land-use studies are minimised.

- (g) Major political boundaries such as the South African/Swaziland border can be seen chiefly because of differentials in intensity of grazing and land-utilization. High contrast and lineal extent tend to overcome the limited resolution of the imagery. Large fields and aggregations of fields can be identified (northern third of 1049-07364) whereas in the turf-pan area (central portion of 1049-07364) the fields are less extensive and essentially obscure. Even colour additive viewing fails to bring this up to a useful image.

3.2 Terrain-type mapping

The technique currently being employed consists of examining 1:10⁶ black and white prints of MSS bands 6 and 7 under the magnification of a simple mirror stereoscope. The enlargement and an 'apparent' slight stereoscopic effect improve the image. Terrain-morphological patterns and individual morphological elements are marked on the prints and transferred to a 1:1 500 000 base map. The information is selectively checked (boundary areas) against aerial photographs and 1:50 000 topographic maps.

The following conclusions have been reached after following this procedure in a number of test areas: terrain-type boundaries are readily identified and in several cases it has been possible to trace such boundaries with greater accuracy and ease than is the case with

conventional methods. Individual morphological features can be identified reasonably consistently - these include mountains, ridges, river valley systems, footslopes, various kinds of lineaments, plateaux, pans, buttes and dunes. Detailed morphometric characteristics which define the morphological patterns must however still be derived from high resolution sources such as aerial photographs and 1:50 000 topographic maps.

4. CONCLUSIONS AND RECOMMENDATIONS

The limitations of the available satellite imagery accepted, there remain sufficient grounds for optimism that the material, particularly if 1:500 000 false colour reproductions can be made freely available, will provide valuable aid in the soil and terrain inventorization program currently being undertaken in South Africa. The terrain-type map of the Republic will be taken from its present second approximation to a final publication edition as a result solely of the satellite imagery. The next phase of the project involving field application of the imagery for purposes of pedosystem mapping is due to commence shortly.

III. EVALUATION AND USE OF ERTS-1 IMAGERY IN PLANT ECOLOGICAL SURVEYS

Co-investigator: Dr D. Edwards

Botanical Research Institute
Department of Agricultural Technical Services
Pretoria

A. AN EVALUATION OF ERTS-1 DATA FOR THE CENTRAL NATAL PROVINCE AREA WITH PARTICULAR REFERENCE TO THE TUGELA RIVER CATCHMENT

Investigator: D. Edwards

1. OBJECTIVES

The objectives are to assess the interpretability and value of the ERTS-1 imagery for the central Natal area, particularly for the Tugela River Catchment (29 120 km² in area) for which there is much information available from previous surveys and investigations.

2. METHODS

Attention was concentrated upon the early spring (early September) ERTS-1 images 1047-07193, 1047-07191 and 1048-07252. Particular attention was paid to the central Tugela River Valley area of image 1047-07193, which is an area of major topographic, climatic and vegetational diversity.

At this stage work has been restricted to laboratory examination and interpretation of the imagery in view of the considerable background information available. Field work will be undertaken after examination of the summer imagery that has now become available.

Initially, difficulty was experienced in interpreting the 1:1 000 000 scale black and white imagery, so use was made of an Additive Colour Viewer that provided easier interpretation. As a result of the experience gained from the colour viewer and improved black and white prints these latter can be better utilized than originally found. There is no doubt, however, that for this diverse region the use of larger scale (1:500 000 or larger) additive colour prints are needed to facilitate interpretation and boundary plotting. It may also be noted that because of the general lack of detection of major roads

and towns, orientation becomes a somewhat tedious procedure resulting in more time-consuming precise image interpretation.

3. RESULTS

Outstanding has been the facility with which burnt areas are recognized and consequently the ease with which the extent and occurrence of these can be determined in relation to vegetation type. On image 1047-07193, for example, it was found that approximately 121 000 ha, or 36% of the vegetation type (veld type) Highland Sourveld represented on this image, was burnt in the period prior to this early spring (8 September) imagery. Recent burning in the remaining seven main veld types covered by this image was negligible. Burning time has been close to that recommended as good conservation practice in the main southern Highland Sourveld area of the photograph, but in the northern parts of the photograph in other grass veld types what are almost certainly old burns have clearly occurred far earlier than recommended by agricultural conservation. Further work on fire imagery will attempt to assess the degree of burn persistence on repetitive satellite imagery.

All large evergreen forests are readily identified, but linear type evergreen forest patches of less than about five hundred hectares in extent have not been readily separated on image character from mesophytic scrub and thicket, and even from exotic afforestation in some instances. Consistent recognition of these mesophytic scrub and thicket patches at the given scale has not been easy, but could be greatly improved by the use of larger scale images for interpretation.

Dense Semi-deciduous Scrub and Succulent Euphorbia tirucalli Scrub and Thicket associations within the dry Valley Bushveld veld type have been identified together with considerable success, but at the given 1:1 000 000 scale their intricate relationship to the rugged Tugela River Valley topography has not permitted consistent recognition and definition for plotting purposes.

Whereas dense scrub phases of the extensive microphyllous Acacia karroo-A.nilotica Thornveld association of the Valley Bushveld veld type have been identified, the more widespread less dense and open Thornveld tree savanna phases are less easily and consistently recognizable. They are not well distinguishable from the surrounding grasslands, a feature which would be of value since approximately 60%

of the Thornveld is of secondary origin. Since this Thornveld is a deciduous formation, it appears that the lack of image registration may well be due to the predominantly leafless condition of the vegetation at this time of year when the imagery was recorded. This appears to be borne out by the generally higher infrared reflectance of similar associations toward the moister warmer coastal regions of image 1047-07193 where earlier leafing takes place. However, similar considerations apply also to the grasslands towards the coast so that at this time of year the hope for differentiation of these two important grass and tree formation classes has not yet been well achieved.

Certain extensive eroded, over- to heavily-grazed poorly vegetated areas are readily identified, but further field work is needed to separate possible correlated soil differentiated imagery. Particularly striking is an example on image 1047-07193 to left of centre. Here the Tugela River forms the northern boundary of a severely eroded area, but the western straight line boundary is that of the Msinga magisterial district. The northern part of this boundary departs from the magisterial district boundary due to rugged dolerite topography that has restricted human and animal influence upon the vegetation.

Along the boundary of Lesotho it has been noted, though not fully investigated, that while the Themeda-Festuca Alpine Veld is very clear the lower subalpine basalt transitions are generally not clearly visible despite the correlation with the change from basaltic to sedimentary geological formations.

Cultivation, irrigation and afforested lands, including the minute peasant patchwork cultivation of the Bantu people in rugged topographic areas, shows up well throughout the ERTS imagery.

4. DISCUSSION AND CONCLUSIONS

Analysis of the early spring ERTS-1 imagery for the central Natal region has revealed outstanding differentiation of the occurrence of veld fires, indicating that for the first time a practical means exists for investigating precisely the location, extent and time of burning in relation to vegetation type, ecology and farming practice. Fire is a major factor in South African plant ecology and in the management of the higher rainfall sourveld areas so that precise knowledge of this factor is of major importance to land management.

In relation to the general objectives of the national vegetation participation proposals, evergreen forests, dense thicket and scrub formation classes are distinguishable, but poor differentiation between open deciduous microphyllous savannas and grasslands was obtained at this time of year. Poorly vegetated secondary areas arising as a result of overgrazing are recognizable and, subject to field checking show promise of satisfactorily providing a monitoring basis for vegetation and habitat deterioration.

The main problems encountered has been the inconsistent display of vegetation boundaries for mapping purposes. To a considerable extent this is a problem arising from the high diversity of vegetation types found in the area of rugged topography on the images studied. Nevertheless, many of the physiognomic boundaries drawn from the satellite imagery have co-incided exactly with those found on existing 1:250 000 vegetation maps of the region. Experience gained and trials indicate that the boundary problem can be overcome to a large extent by the use of colour prints and larger scale print imagery, together with imagery from later in the season.

B. THE IDENTIFICATION AND MAPPING OF REGIONAL HABITAT/ECOLOGICAL TYPES IN THE HIGHVELD GRASSLAND (TEST SITE D)

Assistant Investigators: Mr J.C. Scheepers
Mr N.G. Jarman

1. OBJECTIVES

To establish the use of ERTS data for detecting vegetation and ecological boundaries, in an area which is under intensive and semi-intensive utilization for agriculture.

2. APPROACH

The Highveld, as studied for the report is considered to cover an area 320 km x 350 km (1 120 000 ha). This area has been covered by the three ERTS-1 images; 1049-07304, 1049-07310 and 1050-07362, taken on the 10th and 11th of September 1972. This area has been studied by field staff over the past five years and little actual ground control was required for interpretation. Using the ERTS imagery, vegetation boundaries were established on tone, texture, topography and a number of other features recognisable to workers who know the area well.

The area is almost entirely grassland and intensively farmed. However certain boundaries can be identified.

2.1 Imagery used

Black and white prints of bands 5 and 7 at a scale of 1:1 000 000 in conjunction with additive colour viewing of 70 mm positive transparencies of bands 4, 5 and 7.

3. RESULTS

3.1 Ecological mapping

Working from NW to SE (refer to figures on attached map) the following features were observed:

- (1) Kalahari Sand overburden probably of seif-dune type, orientated \pm NW-SE, extending into the NW Orange Free State in the Odendaalsrust-Allanridge Area. The seif dunes are not visible on the imagery but the boundary of the Kalahari sands is clearly visible due to the light colour of the sanddunes. Associated with this are:
- (2) Kalahari Thornveld being savanna or steppe savanna with Acacia giraffae.
- (3) Deflated Kalahari sand (probably stripped as well) with grassland vegetation and some cultivation.
- (4) On the south bank of the Vaal River are found the Vaal River Sands, recognisable by a particular landuse pattern and the light tone of the sand image.
- (5) To the SE of the Vaal River Sands are mixed sandy soils derived, probably, from the mixture of Kalahari and Vaal River Sands. These sandy soils tend to be much cultivated and again the landuse pattern assists in delimiting the boundary.
- (6) South of the mixed sands is the usually broad shallow Vals-River valley which has been largely stripped of its aeolian sand overburden by the erosion caused by the Vals River and its tributaries. Towards Kroonstad, the Vals River and minor tributaries have incised more deeply into resistant Beaufort-Sandstone and

dolerite giving rise to extensive outcrops of these rocks. Much encroachment by Acacia karroo, has taken place here, and is visible as a dark patch on the satellite image(7).

- (8) A small segment of probably quartzitic ridges (Pretoria Series?) appears to be visible in the north.
- (9) Otherwise the area to the north of the Vaal River carries sourish, secondary veld and Bankenveld eastwards until, north of Vaaldam,
- (10) Bankenveld on Ventersdorp lava is replaced eastwards by
- (11) Turf Highveld or Themeda veld with much cultivation.
- (12) Bankenveld and sourish grassveld also occur on the Vredefort Dome.
- (13) South of the Vaal River Sands there is an extensive area of much-cultivated, partially stripped, partially aeolian-sandy overburden on Karroo (Ecca and Beaufort) sediments. The remaining 'natural' vegetation such as it is corresponds largely to Acocks Dry Cymbopogon-Themeda Veld.
- (14) To the east of 13 lies an area of much-cultivated clayey to rocky land associated with extensive sill intrusions of dolerite forming a minor escarpment along its western boundary. The remaining 'natural' vegetation is or should be dominated by Themeda triandra with a strong affinity with Turf Highveld.
- (15) To the south and east of 14 (i.e. further away from the minor escarpment), a greater extent remains of the formerly more extensive loessic aeolian-sandy overburden which is being stripped from the underlying Upper-Beaufort and Molteno sediments. This area is much-cultivated and much disturbed.
- (16) To the south and east of 15 lies the Mountain Veld of the Orange Free State-Natal-Lesotho border area. This has a typical sour-grassveld vegetation cover.
- (17) At the highest altitudes the Alpine veld of partially evergreen Temperate grasses occurs (Festuca, Danthonia, Pentaschistus, Bromus, Brachypodium, etc.) on Drakensberg basalt.

3.2 Sundry observations (1049-07304)

- (1) Vaal Dam: The Vaal Dam formed at the confluence of two rivers, the Vaal and the Wilge, has two major portions. The tone of the

Wilge River in band 5 and 6 is light grey while the Vaal is black. This suggests that the silt load or quality of the water between the two arms of the dam is different.

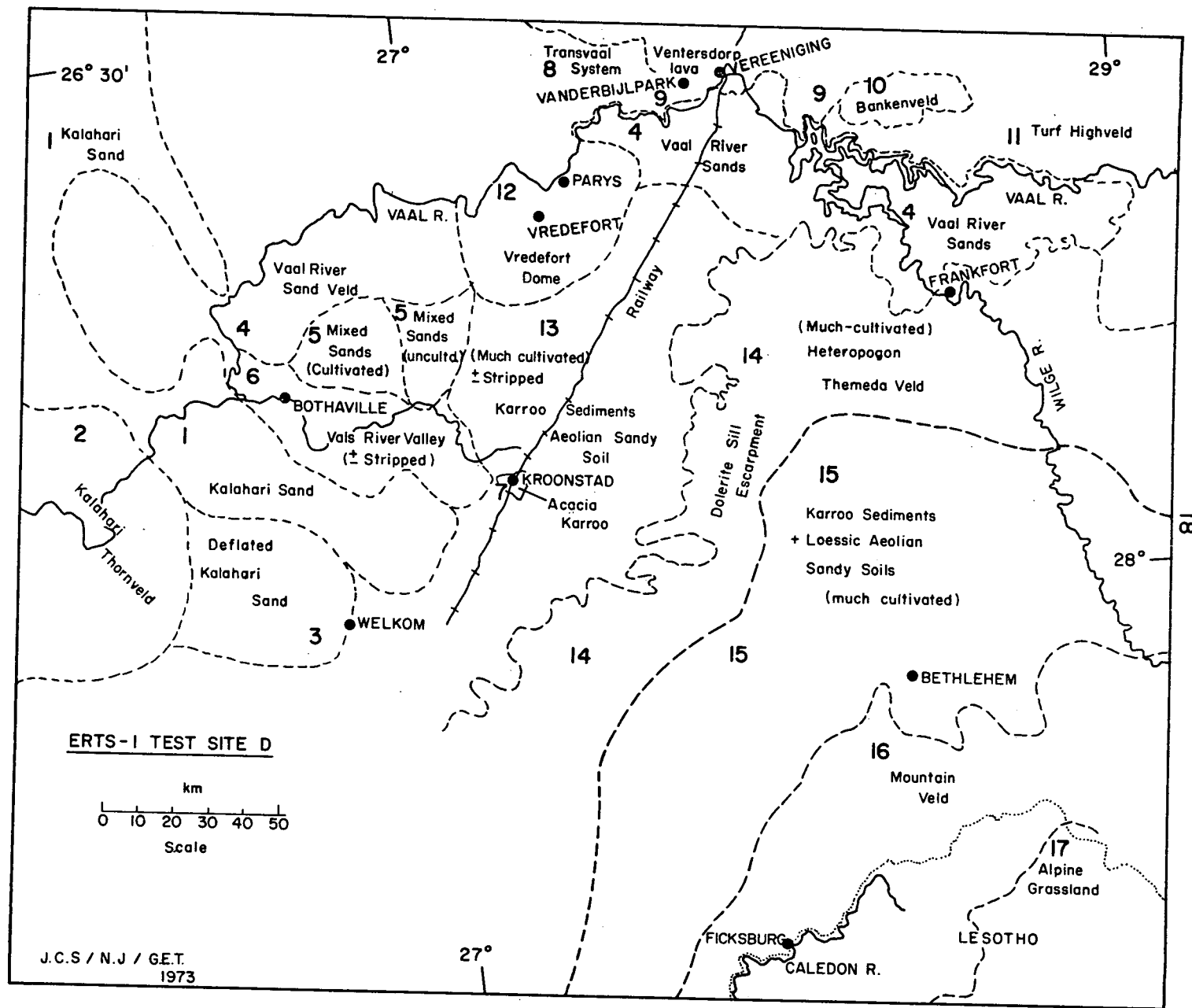
- (2) The Bloemfontein-Kroonstad Vanderbijlpark railroad: This railroad is remarkably clear and there is no obvious reason for this. This feature is visible on all MSS bands.
- (3) Vaal Barrage and bridge: The major contrast in band 7 between water (black) and concrete (white) enables one to see the Vaal Barrage (i.e. dam wall) and a bridge crossing the river immediately below the barrage (at a scale of ca 1:330 000).
- (4) National highway: 15 km of the national road between Villiers and Heidelberg is visible.
- (5) Vaal Dam nature reserve: This area around the perimeter of the Vaal Dam stands out as a result of the surrounding landuse pattern.
- (6) Mining activities: A number of mines could be spotted by their mine-dumps (slag heaps).
- (7) Industrial areas can be seen, e.g. Sasolburg and Vereeniging.

4. CONCLUSIONS

4.1 Vegetation

The highveld is an area generally under intensive agriculture which has largely destroyed the original natural grass vegetation and some ecological boundaries, so that the landuse pattern masks inherently subtle vegetation patterns. Although natural vegetation boundaries were not visible on these photos certain areas can be mapped as land-use units. The imagery, however, should be viewed over a complete season as, in September, when these photos were taken, the grass was bleached yellow by the long dry winter. September, therefore, is probably the worst possible time to attempt a detailed inventory of a grassland area. It is felt that ERTS photos taken later in the season will yield more information.

The vegetation boundary, recognised on these photos of major consequence to ecologists was Acacia karroo invasion of degraded grassveld around Kroonstad. This feature will be further investigated in the field in conjunction with standard aerial photographs.



4.2 Imagery

The original photo prints at 1:1 000 000 were of poor quality which hindered interpretation. Mapping directly from the viewer was not successful because of the effect of parallax.

Coloured prints (i.e. additive colour prints) of good quality would assist interpretation and a two-times magnification to 1:500 000 would facilitate annotation.

C. EVALUATION OF ERTS-1 DATA FOR A PLANT ECOLOGICAL SURVEY OF THE NORTHERN TRANSVAAL BUSHVELD (TEST SITE A)

Assistant Investigator: Mr B.J. Coetzee

1. OBJECTIVES AND APPROACH

Several routes were reconnoitered within part of Test Site A bounded by a line from Pretoria to Ventersdorp, on to Rustenburg, Thabazimbi, Vaalwater and Nylstroom and back to Pretoria (map attached). The purpose was to determine the use of the ERTS-1 photos for a botanical survey at a reconnaissance scale of 1:250 000. The photos were taken on the 10th and 11th September 1972 and on the 16th October 1972, and the field work was done from the 15th to the 18th January 1973.

For the reconnaissance-level classification the test area was subdivided into uncultivated and cultivated landscapes. In the uncultivated landscape the boundary between mountains and lowlands is a major ecological interface. In mountains as well as lowlands the vegetation was subdivided into grassland, savannas, woodland and forest. The main types of savanna recognised are microphyllous deciduous thorn savannas, mesophyllous deciduous savannas and evergreen sclerophyllous savanna. Within a single structurally and functionally defined physiognomic type different vegetation types, based on dominant species, are recognised. Two such dominance types, both from mesophyllous deciduous savanna, were compared to establish whether they could be separated on the ERTS-1 imagery. They were a broad leaved savanna with Faurea saligna dominant and a compound leaved type with medium sized oblong leaflets with Burkea africana dominant. Differences in degree of human impact on uncultivated land were also noted as falling into one of three categories, namely slightly grazed, heavily grazed with good vegetation cover, and over-grazed trampled areas with low vegetation cover.

In cultivated areas old lands with good pioneer grass cover were distinguished from freshly ploughed lands with bare soil, Bantu townships with little vegetation and predominantly bare earth between buildings, cities and other built up areas with tarred roads and vegetated roadsides and gardens.

2. RESULTS

Photos of the four MSS bands displayed essentially the same patterns, with the exception of one photo in band 7 on which an additional unexplained feature appears. Band 6 shows most patterns clearest and can be used alone, while band 5 is preferred for additional clarity. Band 4 is less clear than band 5. Band 7 is similar to band 6, except on photo 1085-07303-7 taken on the 16th October 1972 where, over the Halfway House- Sesfontein-Dryden area, between Johannesburg and Pretoria, band 7 shows an unexplained dark strip that obscures important disturbance patterns.

Previously mapped entities appearing on the ERTS-1 photos include the following:

- (1) Dams, including Hartbeespoort Dam, Bon Accord Dam, Pienaarsrivier Dam, Rietvlei Dam, Bronkhorstspuit Dam, Loskop Dam, Rust de Winter Dam and Klipvoor Dam can be distinguished clearly on bands 6 and 7. On the band 5 photo the dams of the western sector appear black while those in the eastern sector were grey and difficult to see. The reason for this is not known but it is possibly connected with water quality and silt content.
- (2) Drainage lines like the Limpopo, Marico, Crocodile, Sand, Pienaars, Elands, Hex and Marikana Rivers can be clearly distinguished, especially on band 5. Smaller tributaries such as the Hennops and Skeerpoort Rivers, which are hardly visible on band 6 and 7, can still be clearly seen on band 5.
- (3) Mountainous areas such as the Waterberg, Witfonteinrant, Rooiberg, Pilansberg and Magaliesberg are clearly distinguishable on all photos, but particularly so on band 5.
- (4) Cities, including Pretoria and Johannesburg appear clearly on band 6 and 7 as a light grey tone with fine texture.

- (5) Roads can mostly not be distinguished on the photos, a notable exception being a 14 km straight section of the provincial right of way, with a dirt road, between Mabula and Leeupoort, which stretches through fairly homogeneous and undisturbed mesophyllous deciduous savanna on granite soils, and which can be seen clearly on band 5. Other bands of this particular area were not studied. On photos of the Soutpan area near Pretoria, however, it can be seen that the cross-roads at Soutpan are the clearest on band 5.
- (6) Disturbed areas can also be identified on the ERTS photos. A large expanse of cultivated smallholdings such as those immediately north of Pretoria, or those between Pretoria and Johannesburg, large areas of farmlands such as the maizelands between Magaliesberg and Derby, big Bantu townships such as Mabopane, Boekenhout and Hammanskraal, differ in appearance on the photos, and can be mapped. Smaller isolated farmlands, oldlands with pioneer vegetation, severely trampled areas and Bantu townships can, however, not be distinguished from one another on the photos without ground control and appear collectively as disturbed areas.
- (7) The temporary effect of fire on the appearance of vegetation accounts for most of the remaining pattern on the photos. Different stages of recovery from fire appear as different tones of grey, the darkest representing those areas most recently burnt. Other dark areas represent either shadows from high cliffs, forest or dense woodland as in the Renkins Pass area. The use of bands 5 and 7 prevents misidentification between vegetation and non-vegetation due to the high infrared reflectance from dense forest, thicket and scrub vegetation. The different physiognomic types of vegetation require field checking for a positive identification.

Grassland, mesophyllous deciduous savannas, microphyllous deciduous thorn savannas, evergreen sclerophyllous savannas, and different dominance types of mesophyllous deciduous savannas could not be identified as such on the ERTS-1 photos. Grazed veld in good condition did not appear different on the photos from ungrazed veld in good condition.

3. DISCUSSION

The images on the September and October ERTS-1 photos can, with the exception of a dark zone on one band 7 photo, be interpreted. The value of these images for Botanical surveys are:

- (1) The major ecological interface between mountainous areas and low-lands can be mapped.
- (2) Dense woodland and forest can with some field checking be separated from grassland and savanna.
- (3) Cultivated areas together with trampled land can be distinguished from uncultivated land in good condition, but field checking is necessary to distinguish trampled land from cultivation and Bantu townships. It is therefore possible also to monitor either the expansion of trampled land and cultivated areas, or the recovery of trampled land.
- (4) The ERTS imagery also offers the opportunity to monitor burning although the effect of a burn can be reduced to such an extent within one month as to make field work necessary to distinguish between unburnt land in good condition and moderately overgrazed burnt land on black and white prints. Since fires are spread over a period longer than one month, chiefly from Autumn to Spring, it will be necessary to obtain monthly imagery (early as well as late spring photos) for such monitoring to get an accurate picture of the burning regime.

These findings are all based on photos taken in September and October when the difference in colour between grassland and savanna and between mesophyllous and microphyllous savannas is minimal. During the period 20 to 28 September 1972, all grasslands and savannas that had not yet been burnt, as well as those that had been burnt, still maintained in the Rustenberg control area, their dry winter aspect, and only close examination showed that isolated trees were in an early stage of budding. Furthermore, most burning in the Rustenberg area occurred between the 6th of August and the end of September, so that the over-riding effect of burning was maximal during the period of photography. The difference in colour between grassland and savannas is most marked in late summer when the grass is already straw-coloured, the trees still green, and the land

LEGEND OF ROUTE

- a Rural area.
- b Microphyllous Deciduous Thorn Savanna.
- c Farmlands
- d Grassland
- e Mesophyllous Deciduous Savanna.
- f Bantu Township.
- g Microphyllous Deciduous Thorn Savanna (burnt on western side of road).
- h Bantu Township.
- i Microphyllous Deciduous Thorn Savanna.
- j Micro (trampled).
- k Trampled Savanna.
- l Mesophyllous Deciduous Savanna.
- m Right of way clearly visible on 1050-07353-5.
- n Mesophyllous Deciduous Savanna.
- o Grassland.
- p Farmland.
- q Old farmland with pioneer grass cover.
- r Cliffs.
- s Evergreen Sclerophyllous Savanna.
- t Dense Woodland.
- u Old lands with grass cover.
- v Farmland.
- w Microphyllous Deciduous Thorn Savanna.
- x Mesophyllous Deciduous Savanna in good condition. Various stages of recovery from burning.
- y Microphyllous Deciduous Thorn Savanna in good condition.
- z Revegetated (pioneer grass) farmlands.
- aa Mesophyllous Deciduous Savanna in good condition.
- bb Microphyllous Deciduous Thorn Savanna.
- cc Trampled Microphyllous Deciduous Thorn Savanna.
- dd Unburnt Microphyllous Deciduous Thorn Savanna.
- ee Burnt Microphyllous Deciduous Thorn Savanna.
- ff Fire on 6 August 1972.
- gg Farmland

unburnt, so that the chances are optimal to detect this important difference in vegetation on the photos. Colour differences between various types of savanna are also more marked in summer than in winter and early spring, especially where dominant species such as Combretum apiculatum have a conspicuous colour. A disadvantage of autumn photos could be that the same savanna type throughout a large area will not change colour simultaneously due to differences in, for example, rainfall. If, however, the photos are taken in autumn most savannas may well have attained maximum colour differentiation. After a dry season the autumn aspect will appear earlier than after a good season such as 1972, so that this also determines the optimum time for autumn photography. Autumn photography, should therefore be able to be done at relatively short notice at a date to be determined by field checking.

For late summer and autumn photos a range of wavelengths is again desirable for determining the full potential of such photos under these special conditions.

D. THE IDENTIFICATION AND MAPPING OF EXTENSIVE
SECONDARY INVASIVE AND DEGRADED ECOLOGICAL
TYPES (TEST SITE D)

Assistant Investigators: Mr N. Jarman
Mr O. Bosch

1. OBJECTIVES

To attempt to recognise areas which have been degraded over the last twenty years by comparing ERTS imagery with Acock's Veld Types of South Africa (1953).

2. METHOD

Examination of black and white prints of bands 5 and 7 at a scale of 1:1 000 000 were used in conjunction with additive colour viewing of 70 mm positive transparencies.

C

3. RESULTS

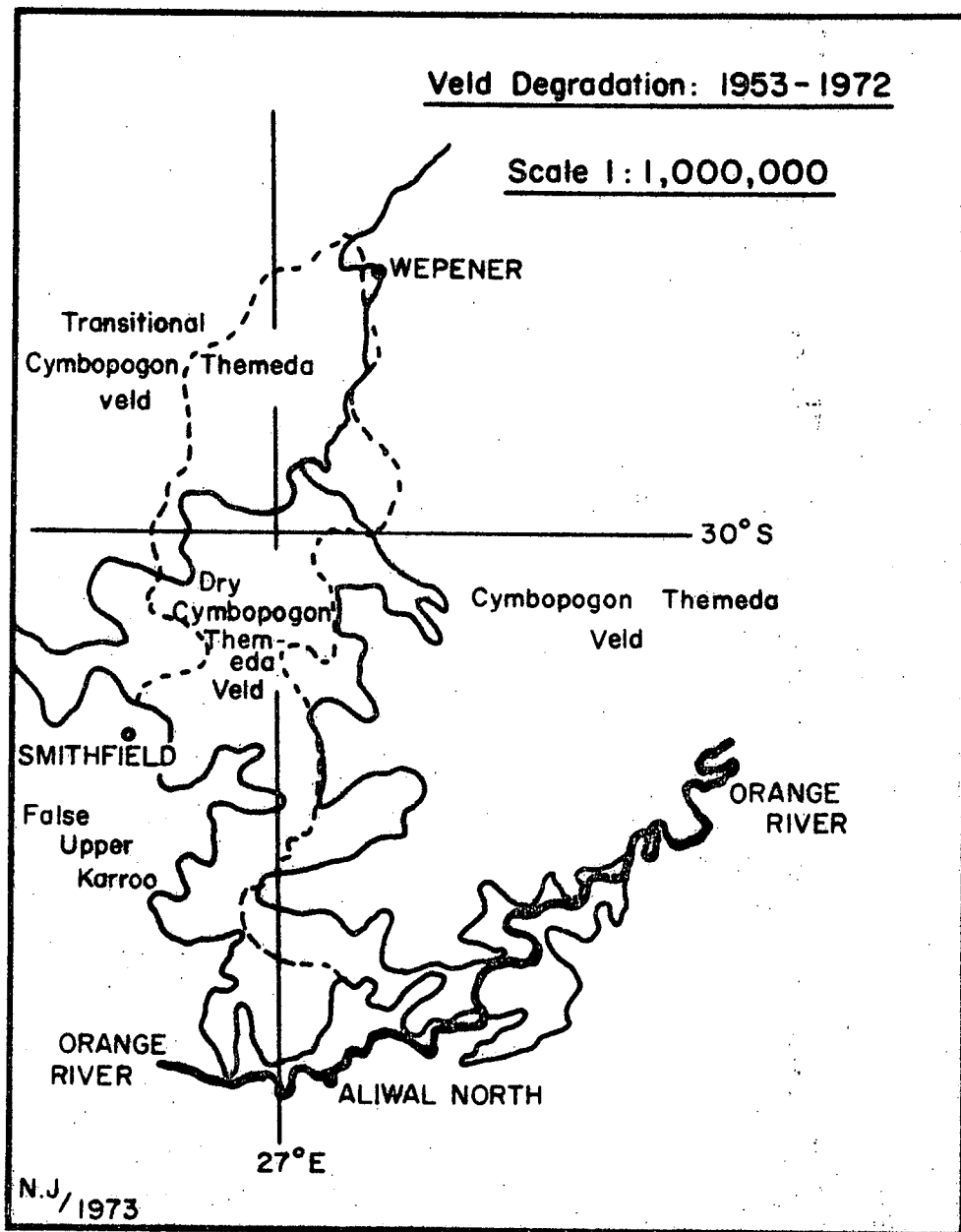
On the ERTS imagery (1049-07313) of 10 September 1972 certain patterns in the vegetation, accentuated by topography, suggested that the boundary of the False Upper Karoo, a dwarf shrub type of vegetation, was no longer in the same position as plotted by Acocks in 1953. A map of the newly degraded area was drawn from the ERTS imagery and superimposed on Acock's Veld Type Map and the boundary appeared to have moved approximately 70 km, invading a grassed area (see attached map). Discussions with people with knowledge of the vegetation of the area confirm that the ERTS imagery is showing up a migrating vegetation boundary. The actual accurate plotting of the boundary remains to be done, but movement of the boundary has been verified by two botanists who have worked in the area.

The next phase in this project will be to establish this boundary on the ground and then with the aid of ERTS imagery determine the extent of the False Upper Karroo migration over its full length.

4. CONCLUSIONS

It appears that ERTS imagery has successfully detected an area of degradation of grassland to dwarf scrub. The exact position of the boundary has yet to be accurately established.

Ref. Acocks, J.P.H., 1953. Veld Types of South Africa. Mem.Bot.Surv.
S.Afr. No. 28.



Dotted boundary delimits grassed area (Dry Cymbopogon-Themeda Veld) which has been invaded by dwarf scrub communities (False Upper Karroo)

IV. PRELIMINARY GEOLOGIC INTERPRETATION OF ERTS-1 IMAGERY

Co-investigator : Dr W.L. van Wyk

Assistant Investigator: Dr R.C. Rhodes
Geologic Survey
Department of Mines
Pretoria

1. OBJECTIVES

To determine how studies of ERTS-1 imagery will assist in the analysis and interpretation of major geological structures and tectonic trends in South Africa. This work has application to the identification of potential areas of economic mineralization.

2. SCOPE OF ACTIVITY

Black and white prints 1:10⁶ scale (mainly MSS bands 5 & 7) of most of South Africa became available in December 1972. Owing to the short time available, this report is preliminary and conclusions reached are tentative. Studies have been restricted to two major areas: (1) central and northwestern Transvaal (1049-07295 and 1050-07353), and (2) south-eastern Transvaal and north coastal Natal (1047-07184, 1047-07191, 1047-07193 and 1010-07131). Studies of these areas have been supplemented by inspection of images covering parts of the Karoo basin and Cape fold belt (1049-07315, 1049-07322, 1050-07371, 1050-07373, 1050-07380, 1069-07425, 1069-07432 and 1069-07434).

3. DISCUSSION

3.1 Geomorphology

Preliminary inspection of ERTS-1 images suggests potential use in geomorphological studies. Regional physiographic differences are clearly visible, for example between the undulating highveld and dissected terrain of the eastern Transvaal lowveld. These contrasting areas are commonly related to different cyclic erosion surfaces. Geomorphological studies on specific drainage basins may be aided by the satellite imagery, especially in dissected terrains where even second- and third-order streams are shown and the drainage pattern is accurately portrayed.

The Zululand coast is characterized by a series of sand spits that dramatically illustrate the prevailing northward movement of longshore drift. Farther inland, short parallel lineaments on the coastal plain probably represent sand dunes, many of which may be old stabilized features. Shallow coastal lakes and estuaries such as St. Lucia show mud flats traversed by meandering streams; a series of images may assist in studies of silting, perhaps related to climatic changes in the interior.

3.2 Lithology

In general, considering the relatively advanced state of geological mapping in South Africa, satellite imagery is not particularly useful for delineating contacts between different formations. For example, an attempt was made to distinguish plutons of Bobbejaankop granite in the Bushveld granite batholith, but was unsuccessful. Similarly, lithologic differences between various Karoo formations are not readily apparent.

Exceptions to this include the Lebombo region, where Karoo rhyolites can be distinguished from the underlying basalts. Also, the on-lapping Cretaceous coastal sediments in Zululand and north of Port Elizabeth are sharply differentiated from older rocks, but the contact mapped from the satellite images does not significantly improve upon that shown on the 1:1 million geological map. In the Barberton and Pongola areas batholiths of granite intrusive into structurally coupled Precambrian strata are recognizable.

3.3 Regional Tectonics

The most promising geological application of ERTS-1 imagery is in the field of regional tectonic synthesis. Lineaments, folds and structural contours can be traced on the satellite imagery and in many cases are better displayed than on conventional aerial photographs or in the field. The ERTS-1 imagery would make an excellent starting point for a detailed tectonic map of South Africa which would be extremely useful in many branches of geology.

3.3.1 Lineaments

The best represented structural features on the satellite images are lineaments, for the most part representing intrusive diabase dykes. The Barberton-Swaziland-Pongola area was studied in detail and a strong

northwest system of lineaments was identified, corresponding to the Pre-Karoo dyke pattern shown on some detailed geologic maps of the area. Some individual lineaments can be followed for over 100 km, far exceeding their recognized length on published maps. A weaker northerly lineament system, parallel to the Lebombo monocline, may represent younger dykes of post-Karoo age. Detailed inspection of the images also revealed local fracture patterns related to folding of the Precambrian strata.

A detailed study of the Waterberg Plateau in the northwestern Transvaal showed a more complex lineament pattern. Individual lineaments there can be followed for several tens of kilometres and in some places the lineated texture is so fine as to exceed the resolution of the images. A northwesterly set predominates, with a second set at right angles and a weak orientation in a north-south direction. A statistical analysis of these lineament orientations is in progress with the object of comparing results with similar studies on conventional aerial photographs and recent available geological maps. This will give us an idea of the comparative value of each set of data, and assist in future interpretation of lineaments mapped from satellite imagery.

The Tugela fault in Natal is prominent on the images and can be traced for more than 150km before disappearing beneath cloud cover west of Colenso. A system of subsidiary lineaments to the north and south of the fault indicate that it is actually a fault system, probably forming an important hinge zone south of the Lebombo monocline. The western end of the fault does not coincide with its counterpart shown on the 1:1 million geological map.

3.3.2 Folds

Folded Precambrian strata in the Barberton-Pongola area can be seen on the satellite images and a regional structural pattern can be made out. Unfortunately, structural trends in the crystalline basement of Natal and the northern Transvaal are not visible on the images, probably owing to the low physiographic contrast between the metamorphic gneisses, schists, etc. Younger folding in the Cape Ranges is spectacularly displayed with clearly visible plunging anticlines and synclines.

3.3.3 Structure contours

Unfolded strata with dips of 20° to 50° produce structural patterns on the ERTS-1 images. The easterly-dipping volcanic rocks of the Lebombo monocline are clearly visible as a north-trending belt. The inward-dipping Transvaal quartzites around the Bushveld Complex produce a basin-shaped structure outlining the igneous complex. Waterberg sediments in the Nylstroom syncline and near Loskop Dam also show up well on the images.

3.3.4 Karoo dolerites

Undulating sills of dolerite in the Karoo and Natal produce recognizable features such as escarpments and distinctive basin structures. These can be easily mapped from the images and have potential application to geomorphology and ground water studies.

4. CONCLUSIONS AND RECOMMENDATIONS

The most valuable attribute of ERTS-1 imagery is its high resolution yet small scale. The images cannot replace conventional photogeology or field mapping, but supplement these techniques and assist in regional geological synthesis. Their most important application is in regional tectonic analysis since the dominant structural trends in any given area can be mapped and evaluated in a fraction of the time (and at a fraction of the cost) of conventional investigations. The imagery could form a basis for compiling a $1:10^6$ tectonic map of South Africa that would have wide application in geology and in the identification of areas of potential economic mineralization. This may prove to be the most important function of currently available satellite imagery.

V. EVALUATION OF ERTS-1 IMAGERY FOR URBAN AND REGIONAL LAND USE SURVEYS

Co-investigator : Mr J.J. la Grange

Assistant Investigators: Mr L. Claassen
Mr J.G. van Zyl
Department of Planning
Pretoria

1. OBJECTIVES

To assess the value of ERTS-1 imagery in the expedition of urban and regional land use mapping and inventorization for planning purposes.

2. METHOD

For interpretation purposes black and white prints of MSS bands 4 to 7 at a scale of approximately 1:10⁶ were used. Particular attention was paid to the most urbanised area in the Republic, namely the Pretoria-Witwatersrand area. This area and its environs contains most land uses and is, in addition, known to the investigators. Two sets of ERTS images of this area were available: 1049-07301 taken on 10 September 1972 and 1085-07303 taken on 16 October. Of these the October images proved to be far superior.

The only instrument used in interpreting the photographs was a stereoscope of 6X magnification, which considerably facilitated interpretation. The clearest images under the stereoscope were obtained in the spectral band combination M.S.S. 5 and 7, with 6 as a good control. The fourth spectral band is difficult to interpret from the black and white prints as definition was poor.

3. RESULTS

The following land uses, shown on the accompanying map, were identified on the photographs:

3.1 Urban areas

- (1) The extent (or boundary) of urban areas is clearly visible. It appears that newer residential areas have a lighter tone than the older suburbs, probably due to, inter alia, the difference in planting.

- (2) The central business district is noticeably darker than other built-up areas of the city.
- (3) The main railway network can be easily identified in urban areas, especially where two or more tracks occur, or where a railway is adjacent to a road. The most important shunting yards in the two large urban complexes can also be distinguished.
- (4) Tarred roads are not so conspicuous. Where a freeway is still under construction, its route is clearly discernible.
- (5) Large open areas in the city, for example golf courses, are conspicuous because of their contrast with the surrounding built-up area.
- (6) An international airport is easily identifiable by the main runway, which is visible without the use of the stereoscope.
- (7) The so-called 'urban fringe', a transition area of small holdings between town and country, is also distinguishable, because of its characteristic intensity of land use.

3.2 Rural areas

- (1) The gold mining areas stand out very clearly.
- (2) Storage dams are very easily identifiable, especially in the spectral band MSS 7. It is of interest that two dams, situated in the same catchment area cannot be identified in the MSS 5 band, while other dams in another catchment area, on the same photograph, can be seen. This can probably be ascribed to the presence of silt in the water.
- (3) The type of agriculture and the intensity of cultivation is very clearly discernible. It was possible to identify irrigated areas, also intensive and extensive dryland cultivation.

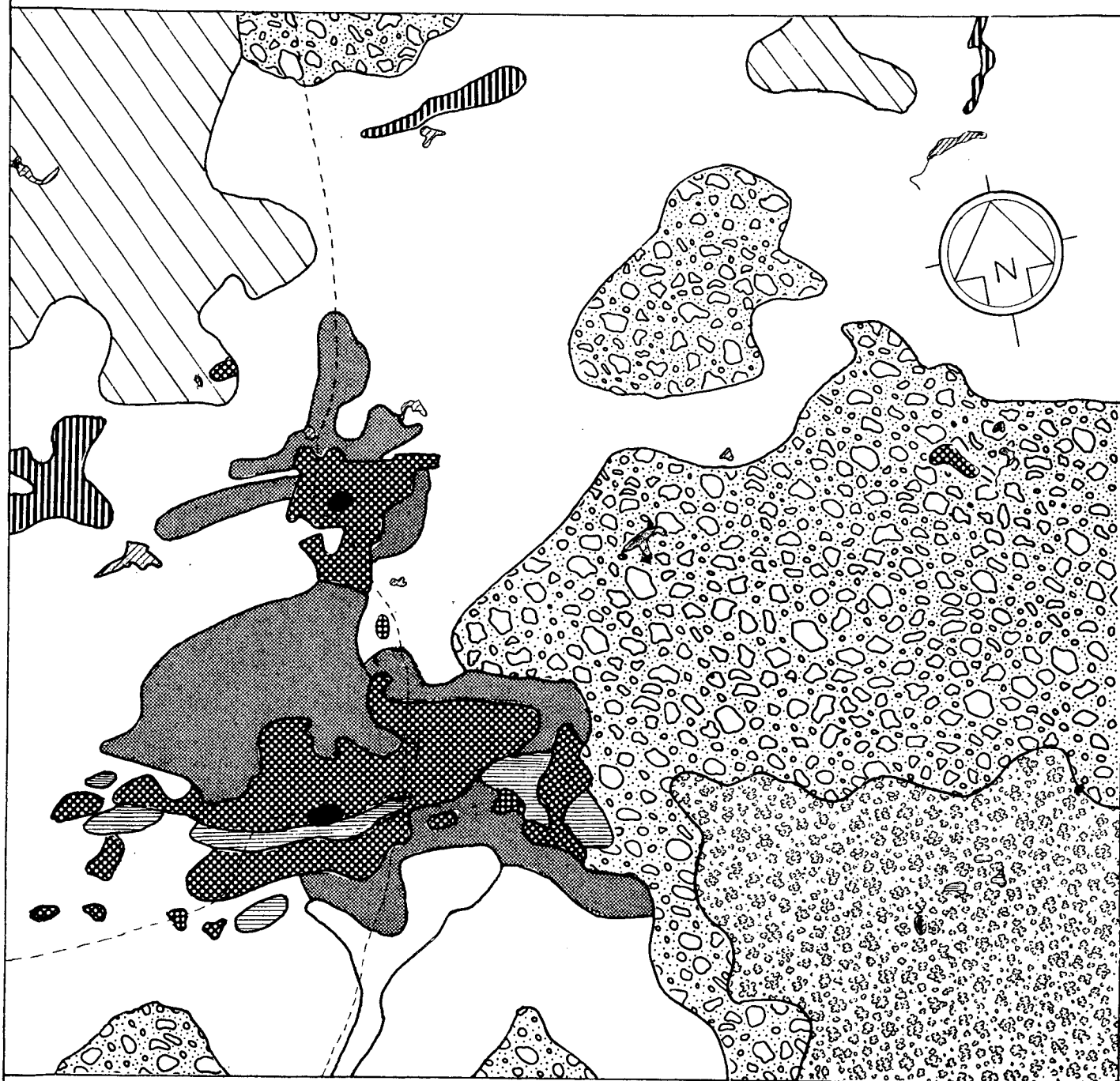
In two cases, land which has been overworked by wrong farming methods can also be identified, by its contrasting lighter tone to its surrounding agricultural areas.

4. CONCLUSION

It is concluded that ERTS imagery can make a significant contribution to regional land use mapping and other characteristics that vary seasonally in a regional context. Air pollution during the critical winter months will be one of the aspects that will receive further attention in future. The available photographs were taken at times when there was little air pollution and this aspect was therefore not evaluated.

LAND USES AS IDENTIFIED FROM E.R.T.S.-A IMAGES

PRETORIA - WITWATERSRAND AREA



REFERENCE

A. URBAN LAND USE



C.B.D.



Urban development. (Built - up areas)



Urban fringe. (small holdings)

B. RURAL LAND USE



Storage Dams.



Irrigation farming.



Intensive Cultivated areas.



Extensive Cultivated areas

} Drylands



Exhausted Agricultural Land.

C. OTHER LAND USE



International Airport.



Mining Areas



Main Transportation Corridors.

VI. SIGNIFICANT RESULTS : DISCIPLINE 10A

1. SOIL AND TERRAIN MAPPING : DISCIPLINE 1D

Application of ERTS imagery to the final preparation of the first detailed small-scale (1:1 500 000) terrain-type map of the Republic of South Africa has revealed its potential usefulness and value in respect of the following:

- 1.1 The imagery is capable of providing a primary information base which is adequate and in many respects superior to other, more conventional sources of data on broad-scale terrain patterns, mainly because the latter (e.g. air-photos, topographic maps) are too detailed, too voluminous, and non-synoptic.
- 1.2 The imagery is particularly valuable in the case of areas for which there may be no conventional air-photographic or topographic coverage.
- 1.3 Costly outlay in acquiring all available air-photography and topographic coverage is eliminated, since with the satellite imagery as the primary and continuous base it has become necessary only to acquire and study conventional coverage of preselected control sections or test areas.
- 1.4 The practical problems and drudgery associated with the analyses and sorting of massive volumes of large-scale photographs and maps in a small-scale study such as this are eliminated. In other words, the scale of the latter is inappropriate to a study such as this, whereas that of the satellite imagery is tailor-made. The savings in capital outlay, time and fatigue are difficult to assess quantitatively at this stage but they are believed to be considerable.

2. PLANT ECOLOGICAL MAPPING : DISCIPLINE 1C

Evaluation of results obtained so far from interpretation of ERTS-1 imagery for vegetation and plant ecological survey must take into account the fact that the images evaluated were those of September and October which represent the early spring months when vegetation differentiation is minimal and that over much of South Africa one of the worst droughts on record occurred during the year 1972. For image evaluation this has accentuated and prolonged the lack of image differentiation of vegetation. Nevertheless the following very significant results have been obtained:

- 2.1 Grassland covers about 30 000 000 ha, or 26% of South Africa, whereas savannas and semi-desert dwarf shrub Karoo in both of which grass is a subordinate or at most complementary synusial component of the ecosystem cover, respectively, 31% and 35% of South Africa. Estimates indicate that over about two-thirds of South Africa pasture research now and in the future will largely be directed towards maintaining and providing for an adequate grass component in either a Karroid dwarf shrub steppe or a savanna type ecosystem, for the conventional pastoralist relies almost entirely upon this grass component. However, the most serious and extensive degradations of vegetation have actually occurred in the Karoo and savannas and in their immediately adjoining grassland areas, which they have invaded over large areas. Most spectacular of these vegetation movements is that of Karoo dwarf shrub into grassland, which over twenty years ago was estimated at over 12 000 000 ha, or over 10% of South Africa. (Acocks, 1953. Veld Types of South Africa. Mem.Bot. Surv. G.Agr. No. 28).

Updating of information concerning the Karoo invasion of grassland is, therefore, of major national concern. The preliminary finding that the ERTS-1 imagery has successfully detected such an area of degradation of grassland into dwarf scrub, and that the former boundary appears to have moved a distance of approximately 70 km, is of major significance. The identification of major areas of erosion and poor vegetation cover is of major significance to the pastoral industry, for which the export

value of the major wool industry alone amounted to R107 600 000 during the year 1969. Positive identification of these critical degraded areas (for which estimates vary widely) on a national scale is, despite the urgency of the need, posing considerable difficulty because of shortage of personnel. Preliminary results from the ERTS-1 imagery indicate that this can be carried out with available personnel and the minimal amount of additional field expenditure, amounting to probably less than R1 000 per officer per annum.

- 2.2 The ERTS-1 imagery has also demonstrated the detection of important physiognomic types of vegetation such as evergreen forests and various dense scrub and thicket types. The detection of evergreen forests is currently of major interest to conservationists since their preservation was the subject of a specific recommendation from the national conservation section of the recent International Biological Programme. Determination of the distribution character and extent of evergreen forest has for many years had to take second place to other commitments by ecologists. Detection of these forests is difficult and time-consuming owing to their patchy distribution in the most rugged topographic areas over a total area of some 15 208 000 ha in the eastern and southern parts of South Africa. As a result of the preliminary promising results obtained from the ERTS imagery an immediate attempt is being made to provide as soon as possible the necessary factual basis for the implementation of the IBP/CT recommendations. The project is of conservation urgency in view of the uncertainties arising from the political development towards independence of the Bantu peoples in the Transkei, Zululand and Eastern Transvaal. The satellite imagery is thus enabling a project to be carried out which would not otherwise have been possible without the creation of extra funding and man-power, roughly estimated at R300 000 per year with an extra technical staff of 10 persons.
- 2.3 A most significant and unanticipated result of the evaluation of the ERTS-1 imagery has been the facility and accuracy with which burning and burnt areas can be detected. This has immediately made possible a project to evaluate the extent and occurrence of

fire in South Africa. Such a project by conventional means would be completely impractical on a national scale, for it would involve manning a monthly remote sensing programme over 100 000 000 ha. Apart from providing an essential basic understanding of the actual role of fire in the vegetation and pastoral ecology of the country, the project will indicate precisely those areas, social and economic farmer groups, vegetation, ecological and climatic types where fire is a management factor. Despite the considerable amount of thorough experimental research that has been carried out on fire and vegetation in South Africa over the past forty years, the actual frequency, timing and location of burning as a pasture management operation has never actually been determined. This is of particular pastoral importance for though fire is generally accepted as an often necessary veld management operation, it is also recognised that this only applies under particular ecological and management conditions.

3. GEOLOGY : DISCIPLINE 3K

Identification of the following features demonstrates how dominant structural trends may be identified and mapped from ERTS imagery at a fraction of the cost of conventional investigations:

- 3.1 The Tugela fault in Natal is characterized by lineaments both to the south and the north which indicate that this is a fault zone rather than a single fault. Also the western part of the fault does not coincide with its counterpart on the 1:1 million geological map of South Africa. This will be investigated in the field as this was not apparent on existing photographs or on published maps.
- 3.2 North-south striking lineaments are characteristic of the Lebombo monocline and these seem to be cut off by the Tugela fault which may constitute an important hinge zone. This was not apparent on ordinary photographs nor from field mapping.
- 3.3 Numerous lineament patterns are recognized, some of which are longer and more extensive than on the published maps or on the older aerial photos.
- 3.4 The inward dipping Transvaal quartzites around the Bushveld Complex were not all that clear on conventional photos or in the field.
- 3.5 Folds in the Cape System near Port Elizabeth are significant and are more easily distinguished from the ERTS images than ordinary photographs or in the field.

Analysis of all available imagery could form the basis of a 1:10⁶ scale tectonic map of South Africa that would have wide application in geology and the identification of areas of potential economic mineralization.

4. REGIONAL LAND USE MAPPING : DISCIPLINE 2A

Investigation of ERTS imagery of the Johannesburg-Pretoria region which covers highly urbanized as well as uncultivated rural areas have clearly indicated that these photographs can be a very important source of information in future land use studies of South Africa. The Republic is well supplied with large-scale topo-map series and complete conventional airphoto coverage is already available. The relatively large scale at which this coverage is available makes the study thereof a protracted and expensive process for sub-national and regional purposes. The researcher is confronted with a wealth of information which is apt to confuse the analysis. The view is therefore held that ERTS imagery can make a special contribution towards land use surveys on a sub-national, regional and sub-regional level by significantly accelerating the survey and lowering the cost. The opinion is held that the photo-scale is too small to provide worthwhile results regarding urban land use.